bitter, and astringent taste. A substance with exactly the same properties was obtained from the acid which was used to act upon the hydrocarbons $C_6 H_{10}$.

I am at present engaged upon experiments to isolate the hydrocarbons $C_n H_{2n-2}$ contained in coal-tar.

IV. "The Calculus of Chemical Operations; being a Method for the Investigation, by means of Symbols, of the Laws of the Distribution of Weight in Chemical Change. Part I.—On the Construction of Chemical Symbols." By Sir B. C. Brodie, Bart., F.R.S., Professor of Chemistry in the University of Oxford. Received April 25, 1866.

(Abstract.)

In chemical transformations the absolute weight of matter is unaltered, and every chemical change, as regards weight, is a change in its arrangement and distribution. Now this distribution of weight is subject to numerical laws, and the object of the present method is to facilitate the study of these laws, by the aid of symbolic processes. The data of the chemical calculus, as indeed of every other application of symbols to the investigation of natural phenomena, are supplied by observation and experiment; and its aim is simply to deduce from these data the various consequences which may be inferred from them. The province of such a method commences where that of experiment terminates.

This part comprises the consideration of the fundamental principles of symbolic expression in chemistry, and also the application of the method to the solution of perhaps the most important of all chemical problems, namely, the question of the true composition, as regards weight, of the units of chemical substances.

Section I. In the first section certain definitions are given of those weights and relations of weight, of which the symbols are subsequently considered. It may be regarded as containing an analysis of the subject of chemical investigation. The definitions are of "a chemical substance," "a weight," "a single weight," "a group of weights," "identical weights," "a compound weight," "a simple weight," and "an integral compound weight."

The unit of a chemical substance is defined as that weight of the substance which at 0° Centigrade, and 760 millims. pressure and in the condition of a perfect gas, occupies the volume of 1000 cubic centimetres. This volume is termed the unit of space.

Section II. The second section treats of symbolic expression in chemistry. A "chemical operation" is defined as an operation of which the result is a weight. These operations are symbolized by letters, x, y, &c. An interpretation is assigned to the symbols $+$ and $-$, as the symbols of aggregation and segregation, that is, of the mental operations by which groups are formed. The symbol $=$ is selected as the symbol of chemical identity; the symbol

0 as the symbol of the absence of a weight, this symbol being identical with $x-x$. The symbol $(x+x)$ is the symbol of two weights collectively considered, and as constituting a whole.

The symbols xy and $\frac{x}{y}$ are selected as the symbols of compound weights, and it is proved that with this interpretation these symbols are subject to the commutative and distributive laws,

$$xy=yx,$$

$$x(y+y_1)=xy+xy_1,$$

and also to the index law,

$$x^p x^q = x^{p+q}.$$

Section III. treats of the properties and interpretation of the chemical symbol 1, which is selected as the symbol of the subject of chemical operations, namely, the unit of space. With this interpretation the chemical symbol 1 has the property of the numerical symbol 1 given in the equation $x1=x$.

Section IV. Chemical symbols are here shown to be subject to a special symbolic law, given in the equation

$$xy=x+y.$$

This property, by which chemical symbols are distinguished from the symbols employed in other symbolic methods, is termed the "logarithmic" property of these symbols. A consequence of this property is that $0=1$, and that any number of numerical symbols may be added to a chemical function without affecting its interpretation as regards weight.

Section V. relates to the special properties of the symbols of simple weights, which are termed prime factors, from their analogy to the prime factors of numbers. These symbols differ, however, from these factors in that, like the numerical symbol 1, they are incapable of partition as well as of division, which is a consequence of the condition $xy=x+y$.

The symbol of the unit of a chemical substance, expressed as a function of the simple weights of which it consists, is identical with the symbol of a whole number expressed by means of its prime factor, a^n, b^{n_1}, c^{n_2}. . . . A general method is given for discovering the prime factors of chemical symbols.

Section VI. is on the construction of chemical equations from experimental data.

Section VII. On the expression of chemical symbols by means of prime factors in the actual system of chemical equations. The object of this section is to prove that the units of weight of chemical substances are integral compound weights, and to discover the simplest expression for the symbols which is consistent with this assumption.

Such an expression cannot be effected unless some one symbol be determined from external considerations. The unit of hydrogen, therefore, is assumed to consist of one simple weight, its symbol being expressed by one prime factor, a, which is termed the *modulus* of the symbolic system.

This assertion is the expression of a hypothesis which may be proved or disproved by facts, and the consequences of which are here traced.

The symbols of the elements are considered in three groups. 1. The symbols of the elements of which the density in the gaseous condition can be experimentally determined, and which form with one another gaseous combinations. 2. The symbols of carbon, boron, and silicon. 3. The symbols of other elements, which are determined with a certain probability by the aid of the law of Dulong.

For the method of constructing these symbols, which depends upon the solution in whole numbers of certain simple indeterminate equations, we must refer to the memoir itself.

The following symbols may serve as an illustration of the general results:—

Name of substance.	Prime factor.	Absolute weight in grammes.	Relative weight.
	α	0·089	1
	ξ	0·715	8
	χ	1·542	17·25
	ν	0·581	6·5
	ϕ	1·305	15
	κ	0·536	6
	Symbol.		
Hydrogen	α	0·089	1
Oxygen	ξ^2	1·430	16
Water	$\alpha\xi$	0·804	9
Chlorine	$\alpha\chi^2$	3·173	35·5
Hydrochloric acid	$\alpha\chi$	1·631	18·25
Oxide of chlorine	$\alpha\chi^2\xi$	3·888	43·5
Hypochlorous acid	$\alpha\chi\xi^3$	2·346	26·25
Teroxide of chlorine...	$\alpha\chi^2\xi$	5·319	59·5
Chlorous acid	$\alpha\chi\xi^2$	3·062	34·25
Chloric acid	$\alpha\chi\xi^3$	3·777	42·25
Nitrogen	$\alpha\nu^2$	1·251	14
Ammonia	$\alpha^2\nu$	0·760	8·5
Protoxide of nitrogen	$\alpha\nu^2\xi$	1·966	22
Nitrite of ammonium	$\alpha^3\nu^2\xi^2$	2·860	32
Chloride of ammonium	$\alpha^3\nu\chi$	2·391	26·75
Phosphorus	$\alpha^2\phi^4$	5·541	62
Phosphide of hydrogen	$\alpha^2\phi$	1·519	17
Pentachloride of phosphorus	$\alpha^3\phi\chi^5$	9·319	104·25
Terchloride of phosphorus	$\alpha^2\phi\chi^3$	6·145	68·75
Oxychloride of phosphorus	$\alpha^2\phi\chi^3\xi$	6·869	76·75
Carbon	κ^y	0·536+y	6+y
Acetylene	$\alpha\kappa^2$	1·161	13
Marsh-gas...	$\alpha^2\kappa$	0·704	8
Alcohol	$\alpha^3\kappa^2\xi$	2·056	23
Ether...	$\alpha^5\kappa^4\xi$	3·308	37
Acetic anhydride	$\alpha^3\kappa^4\xi^3$	4·559	51
Acetic acid	$\alpha^2\kappa^2\xi^2$	2·682	30
Trichloracetic acid	$\alpha^2\chi^3\kappa^2\xi^2$	6·146	68·75
Hydrocyanic acid	$\alpha\nu\kappa$	1·207	13·5
Cyanogen	$\alpha\nu^2\kappa^2$	2·324	26

Section VIII. Certain apparent exceptions are considered, in which it is not found possible to express the symbols of chemical substances by means of an integral number of prime factors, consistently with the assumption of the modulus α.

The Society then adjourned to Thursday, May 17.

May 17, 1866.

Lieut.-General SABINE, President, in the Chair.

The following communications were read :—

I. "On the Motion of a Rigid Body moving freely about a Fixed Point." By J. J. SYLVESTER, LL.D., F.R.S. Received April 26, 1866.

(Abstract.)

The nature of the present brief memoir will be best conveyed by my giving a succinct account of the principal results which it embodies, in the order in which they occur. The direct solution, in its present form, of the important problem of the motion of a rigid body acted on by no external forces, originating in the admirable labours of Euler, has received the last degree of finish and completeness of which it is susceptible from the powerful analysis of Jacobi; in one sense, therefore, it may be said that the discussion is closed and the question at an end. Notwithstanding this, in the mode of conceiving and representing the general character of the motion, there are certain circumstances which merit attention, and which may be expressed without reference to the formulæ in which the analytical solution is contained.

Poinsot's method of representing the motion by means of his so-called "central ellipsoid" has passed into the every-day language of geometers, and may be assumed to be familiar to all. The centre of this ellipsoid is supposed to be stationary at the point round which any given solid body is turning; its form is determined when the principal moments of inertia of that body are given, and it is supposed accurately to roll without sliding on a fixed plane whose position depends on the initial circumstances of the motion. The associated free body is conceived as being carried along by the ellipsoid, so that its path in space, its continuous succession of changes of position, is thereby completely represented; but no image is thus presented to the mind of the time in which the change of position is effected. I show how this defect in the representation may be remedied, and the time, like the law of displacement, reduced to observation by a slight modification of the apparatus of the central ellipsoid or representative nucleus, as it will for the moment be more convenient to call it. To steady the ideas, imagine the fixed invariable plane of contact with the nucleus to be horizontal and situated under it; now conceive a portion of its upper surface, say the upper